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Using a Personalised Socially Assistive Robot for Cardiac Rehabilitation: A Long-Term Case Study

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***Abstract*— This paper presents a longitudinal case study of Robot Assisted Therapy for cardiac rehabilitation. The patient, who is a 60-year old male that suffered a myocardial infarction and received angioplasty surgery, successfully recovered after 35 sessions of rehabilitation with a social robot, lasting 18 weeks. The sessions took place directly at the clinic and relied on an exercise regime which was designed by the clinicians and delivered with the support of a social robot and a sensor suite. The robot monitored the patient's progress, and provided personalised encouragement and feedback. We discuss the recovery of the patient and illustrate how the use of a social robot, its sensory systems and its personalised interaction was instrumental to maintain engagement with the programme and to the patient's recovery. Of note is a critical event that was promptly detected by the robot, which allowed fast intervention measures to be taken by the medical staff for the referral of the patient for further surgery.**

I. INTRODUCTION

Cardiovascular diseases are considered to be the most critical causes of death, representing 31% of the global deaths[1]. Cardiac Rehabilitation (CR) programmes aim to provide aid to those who have suffered a cardiovascular event to accelerate recovery and reduce the risk of suffering recurrent events through structured exercise prescription, education, and risk factor modification [1]. CR is a long-term programme (often lasting 4-5 months) that may result in low adherence rates due to the increasing lack of motivation throughout the rehabilitation procedure [2]. It is, however, vital for patients to complete the programme to ensure a full recovery [3]. Lack of motivation can be addressed by providing individual support within the sessions, such as through rigorous supervising during the patient's exercise and quick support in emergent situations [4]. Moreover, while physical training during the CR is required to enable increased fitness and is safe, there is a rare possibility of it causing serious complications during the programme [2], thus, it is crucial to ensure that the patient is monitored closely during the sessions. However, CR programmes at clinics are generally conducted with large groups, and it is challenging for clinicians to provide continuous and individual monitoring during the session. A personalised socially assistive robot can address these issues by providing individualised care and facilitating a bond with the patient to increase motivation and engagement within the programme, and help the medical staff in continuously monitoring the patient [5], [6].

(a) (b)

Fig. 1. Setup of the system for cardiac rehabilitation programme at Fundacin Cardioinfantil-Instituto de Cardiologa (Bogotá, Colombia): patient interacting with the (a) tablet interface, (b) personalised assistive robot.

One of the grand challenges of socially assistive robotics (SAR) is to create a physically embodied socially assistive agent that is pleasant and valued to interact with for long-term interactions, and demonstrates a marked improvement in training or recovery of the user in a session [7]. Moreover, because the robot is deployed in a real-world with non-expert users (e.g., doctors, nurses, patients), it should be autonomous and require minimal effort from users and medical staff [8].

Aiming to improve the patient's motivation, engagement and adherence to the rehabilitation procedures, we deployed a fully autonomous personalised socially assistive robot in a real-world CR programme at Fundacin Cardioinfantil-Instituto de Cardiologa (FCI-IC) hospital (Colombia), as shown in Fig. 1. Building upon our previous development [9], [10], this work presents an in-depth case study of a patient undergoing the outpatient phase of the CR programme lasting 35 sessions (18 weeks) with the personalised robot. We analyse the effects of the robot through the physiological evolution of a patient throughout the programme, and the perception and feedback of the patient through the Uni-

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[1]World Health Organization statistics: https://www.who.int/en/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

fied Theory of Acceptance and the Use of Technology (UTAUT) [11], [12], [13] and Working Alliance Inventory (WAI) [14] questionnaires and video analysis.

II. RELATED WORK

SAR refers to the application of assistive and supportive robotics which predominantly rely on social interactions [8]. It has been demonstrated to be effective as a therapeutic tool for both children and elderly, including stroke patients and patients going through physical rehabilitation. While the role of the robot can vary greatly across domains, there are several common uses for the robot, such as increasing motivation of the patient, improving task progress and performance, and providing monitoring, feedback and assistance. A number of studies (e.g., [15], [16]) showed the positive outcomes due to the use of socially assistive robots in rehabilitation, however, these studies have mostly been carried out in laboratory conditions or during short-term interventions, which restrict the applicability of the results to long-term therapies in real-world applications.

While short term interactions benefit from the novelty effect for high user engagement, long-term studies require robust and complex systems, because the limitations of the robot often come to the fore with repeated interactions, which may result in a decrease of user interest and engagement [17]. The behaviour of the robot might not be attractive enough to keep up with the patient's expectations, and interest by the patient and medical staff might wane over time, resulting in a declining frequency of use and interaction with the robot [18]. However, as previously noted, maintaining the patient's motivation and adherence to the programme is critical for cardiac rehabilitation. Personalisation (e.g., addressing the patient with their name, and referring to previous sessions) has been shown to have added benefits in improving user motivation and engagement, in addition to creating a sense of familiarity over time, which facilitates rapport and trust over long-term interactions [17], [19]. Clinicians (i.e., nurses, physiatrists, occupational therapists) also identify personalisation, sociability and social presence of the robot as the key elements for motivation, engagement and compliance in a CR programme [13].

In our previous work [9], [10], we described the components of a sensory interface that is used to obtain physiological, spatiotemporal, and exercise intensity parameters of a patient in the outpatient phase of CR, while performing physical exercise on a treadmill. This data, in turn, is used to provide immediate feedback to the patient through a tablet-based Graphical User Interface (GUI) or verbally using a robot. Initial user studies [13], [20] showed that patients and clinicians perceived the system positively and as reliable and robust for CR. Comparison of using a robot to a control condition (only tablet interface) in our system, showed a significant increase in the patients' perceived trust, utility, usefulness and ease of use [13]. However, the clinicians and the patients emphasised the need for an increase in sociability and social presence of the robot. In this work, we aim to address these points through the personalisation of the robot.

III. METHODOLOGY

Cardiac rehabilitation is conducted in FCI-IC through three phases [9]: (I) inpatient phase (within 48 hours after a cardiovascular event), (II) outpatient phase (after the patient leaves the hospital, lasting around 18 weeks, twice per week) and (III) maintenance program (lasting nine months with one or two sessions per week). Among other exercises and an educational program, the outpatient phase contains physical exercises for 20-30 minutes within a group session.

A conventional outpatient CR session consists of three main sub-stages: (i) *warm-up* via stretching exercises, (ii) *training* through physical exercises on a treadmill, and (iii) *cooldown*, in which low intensity exercises are carried out. During the *warm-up* and *cooldown* stages, the medical staff measures the initial and final heart rate (HR), as well as the initial and final blood pressure (BP). During *training*, the medical staff regularly asks for the exertion level of the patient using the Borg Scale (BS) [21].

The *training* performance of the patient depends highly on the intensity of the session, which is determined by the treadmill speed and inclination. The intensity of the session progressively increases through these parameters to improve the physical fitness of the patient [22]. The overall progress of the patient guides the clinicians in determining these parameters. In the face of any problems during the session (e.g., high BS or HR), the intensity should be promptly adjusted by the clinician. However, because of the high number of patients in the programme and the lack of a telemetry in the CR unit, it is very difficult for the clinicians to monitor the patients continuously during the sessions. Thus, our work focuses on providing continuous and personalised monitoring to patients during the *training* stage, thereby supporting clinicians in providing immediate assistance in emergent situations, and helping them focus more directly on the patients.

A. Socially Assistive Robot in Cardiac Rehabilitation

It is important to structure the social human-robot interaction such that the CR programme is not negatively affected, especially considering the medical context, the vulnerability of the patient, the potential of unanticipated events and the typical noise of a real-world environment [23]. Thus, we designed a system in collaboration with medical specialists and arrived at a set of rules for providing and adapting feedback by the robot to the patient.

In order to continuously measure the physiological parameters of the patient and the intensity of the sessions we designed a sensor interface in our previous work [9]: (i) heart rate (HR) and recovery heart rate (R-HR) are estimated with an electrocardiogram (ECG) on the patient during both *training* and *cooldown*, (ii) during *training*, Borg Scale (BS) is regularly requested through a tablet interface on the treadmill console, (iii) the patient's gait, step length, cadence and speed are estimated by a laser range finder (LRF); the inclination is measured by an inertial measurement unit (IMU) on the lower part of the treadmill, (iv) cervical posture of the patient is determined by the gaze direction obtained from the tablet camera [24], and (v) systolic blood pressure (BP) is taken by the clinician at the beginning and end of a session and entered through the tablet interface.

We designed and integrated a fully autonomous socially assistive robot with this sensor interface to enable giving verbal feedback and motivation [9]. We used a NAO[2] robot (SoftBank Robotics Europe) as shown in Fig. 1. The various types of robot's feedback and requests are as follows: (i) announcing the session parameters (speed and inclination of the treadmill) at the beginning of a session, (ii) motivating the patient throughout the session (e.g., *"Let's go! You can do it!"*), (iii) requesting for entry of the Borg scale on the tablet interface at certain periods, (iv) tracking and warning high HR and requesting confirmation from the patient of his health status, (v) requesting correction of the cervical posture to reduce risk of dizziness and falls, (vi) alerting the medical staff in case of exceeded HR or BS values. The warning and critical alert thresholds of HR and BS are determined by the physiatrists based on the progress of the patient throughout the CR sessions. While the high HR warning does not represent a critical situation, it can give an initial warning to the medical staff about the patient's condition. When the medical staff intervenes for the critical HR or BS alert, he/she should touch the head of the robot to end the alert. The Borg requests and high HR confirmation are compulsory, i.e., the robot repeatedly requests these parameters if the patient does not respond within a given time.

B. Personalisation

As previously pointed out, personalisation helps improve user engagement and motivation throughout the sessions, which is critical for adherence to the CR programme. In addition, our previous work [13] indicated the need for increased sociability and social presence. Hence, we designed a personalised socially assistive robot.

We recognise patients through a fully autonomous and online multi-modal user recognition system [25] that allows detecting and enrolling new users, without the need for any preliminary training. The user recognition combines face recognition with soft biometric (e.g., age, gender, and height) estimates obtained from NAOqi[3] software of the robot, and the time of interaction of the patient to offer reliable user recognition in long-term HRI.

In order to increase the sociability of the robot, we personalise the robot's feedback by referring to the patient with his name periodically throughout the session. In addition, the progress of the patient (based on the number of alerts experienced) and the relative intensity of the sessions are tracked, which is used to motivate the patient for the current and upcoming sessions. (i) At the beginning of a session, the current session parameters are announced along with the *relative intensity* of the session and the previous session progress, such as *"In the previous session, you experienced a problem with heart rate. I am sure it will be all fine this time!"*. The *relative intensity* is defined (by the clinicians in FCI-IC) as **higher** if either the speed or inclination of the treadmill is higher than the previous session, and **lower** if both of these parameters are lower. (ii) At the end of the session, session progress is compared based on the relative intensity, e.g., *"We had a lower number of problems in this session than the previous one, even though the session intensity was higher. Let's keep up the good work, PATIENT_NAME!"* or *"We had more problems... Next time will be better!"*. In order to provide only positive feedback (as decided by the clinicians), we removed the comparison of the relative intensity if it was less intense.

We enforce social presence by tracking the attendance of the patient to improve the adherence to the CR program. If a patient does not attend the sessions twice a week except for national holidays, the robot comments on the situation with *"You didn't come to the session last (X) session(s). I hope everything is all right!"*. We also aim to increase positive sociability with date tracking through commenting on the weekend/national holiday, e.g., *"I hope you had a nice weekend/holiday!"*.

These personalisation methods correlate with the therapists' approach in improving the motivation, engagement and compliance of the patient, through feedback, positive reinforcement, reminders and prompts [6].

C. Evaluation Methods

In order to analyse the effects of the robot, *quantitative* and *qualitative* methods were used. The *quantitative* method is described by the physiological data acquired by the interface: heart rate (HR), Borg scale (BS) and systolic blood pressure (BP). In the case of the HR, the most important variables to the clinicians are the HR during the *training* stage, and the recovery HR corresponding to the difference between the HR at *training* and the HR acquired one minute after *cooldown* begins. Additionally, BS and BP were analysed to observe the exertion level and the effects of the exercise.

For qualitative methods, we applied the Unified Theory of Acceptance and the Use of Technology (UTAUT) from our previous work [13], the Working Alliance Inventory (WAI) [14] and conducted a video analysis. The UTAUT questionnaire evaluates the perceived trust, safety, sociability, social presence, ease of use, utility and usefulness of the robot with positively formulated questions, in addition to open-ended questions for recommendations and additional comments. Additional custom questions were used to evaluate the perception and contentment of the personalisation aspects of the robot (i.e., recognition, using patient's name, progress tracking, adherence motivation) corresponding to additional constructs, such as the perceived adaptivity, enjoyment and attitude towards the robot. The WAI questionnaire analyses three indicators (*Task*, *Bond*, and *Goal*) that allows evaluating the long-term interaction, with each item using negative (e.g., *I feel uncomfortable with the help of the robot.*) and positive (e.g., *The robot perceives my objectives of the rehabilitation properly.*) formulations that allows limiting the bias in the results. The video analysis was

[2] https://www.softbankrobotics.com/emea/nao
[3] http://doc.aldebaran.com/2-5

performed by an independent coder, who labelled various types of interactions (i.e., medical staff, posture correction, gaze to the robot, social interaction and response to robot requests) based on a previously-established protocol.

IV. CASE STUDY

This section describes the case study of a male patient (60 years old, body mass index: 25.7 - overweight, high school degree). The patient was diagnosed with myocardial infarction and underwent an angioplasty procedure. After being discharged from the hospital, the patient started the outpatient phase of CR.

Within the first session of the outpatient phase, the patient was informed about the purpose of this study and the role of the robot. Upon this information, the patient gave his informed consent to take part in the study, hence, throughout the remaining 35 sessions of the outpatient phase, the personalised social robot was present and took an active role in supporting and monitoring the session's progress. The 13th session is of note. During that session, the patient experienced fatigue, and his heart rate was very high over a critical threshold. This was detected by the robot and the medical staff were called over for an intervention. The patient was referred to the Emergency Room for a percutaneous transluminal coronary angioplasty plus stent.

This next section will analyse the overall physiological progress of the patient along with an in-depth look at this "critical" session. In addition, the results of the WAI and UTAUT questionnaires and the video analysis are presented in order to observe the long-term perception of the patients.

A. Physiological Progress

While the *relative intensity* of the sessions has progressively increased (visible in Fig. 2), the *very mild* exertion level perceived by the patient and the physiological progress of the patient (Fig. 3) show a positive outcome regarding the patient's cardiovascular health and the success of the CR programme. As we previously indicated, the most important parameters showing the physiological improvement of a patient in CR is the heart rate (HR, Fig. 3a) and the recovery HR (R-HR, 3b). The average heart rate (HR) of the patient mostly stayed below the initial critical level (120 bpm) that corresponds to the robot alerting the medical staff. Moreover, the threshold for the critical value was increased by the clinicians, showing that the physical fitness of the patient

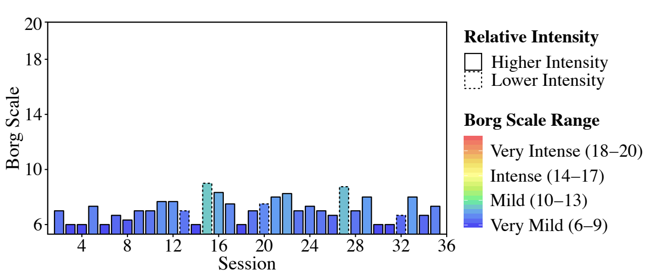

Fig. 2. Exertion levels (Borg Scale) and relative intensity of sessions during the CR programme.

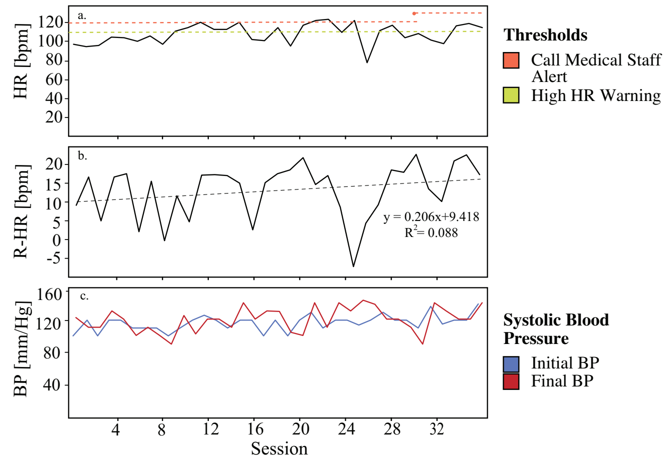

Fig. 3. Physiological evolution of the patient during 35 sessions: (a) Average heart rate (HR) during *training*, (b) Recovery heart rate (R-HR) and (c) Systolic blood pressure (BP).

improved. The recovery HR also tended to increase throughout the session, which was identified by the physiatrists in FCI-IC as a valuable improvement on the patient's health. In addition, the systolic BP (Fig. 3c) was maintained in a safe range (110-130 mmHg) in most of the sessions.

However, the number of alerts in a session (Fig. 4) lights a different perspective than the average HR. While the average HR hardly increased over the critical limit throughout the CR programme, in 9 out of 35 sessions, the medical staff were alerted to help the patient, which was critical to the session. We should note that in the 24th session the number of alerts corresponds correctly to the detected critical rates, but in session 27, there was a problem with the robot's sensors.

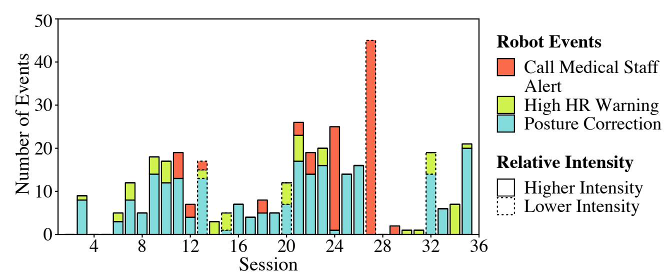

Fig. 4. Robot alerts and warnings for the HR and cervical posture during the sessions.

B. The Critical Session

The 13th session is an important example of the interest of continuous monitoring of patients and social robots. In this session, the participant had a higher HR compared to the previous ones, crossing a critical threshold set by the physiatrists on two instances which resulted in two calls to the medical staff (red dotted points in Fig. 5). The prompt alert of the robot helped the medical staff as a medical tool to immediately detect the complication, such that they can instantly intervene by decreasing the intensity of the exercise. In addition, the alerts in the previous sessions may

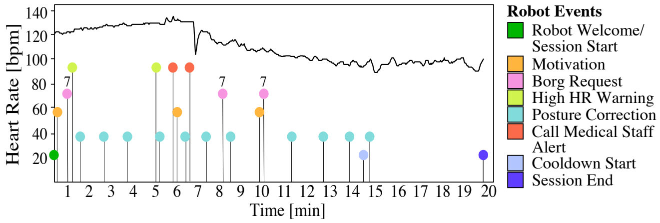

Fig. 5. Patient's heart rate and robot's feedback during the "critical" session.

have increased the awareness of the clinicians to detect the complication. Upon the intervention, the patient reported to the medical staff of feeling dizzy and highly tired, and continued the session with low intensity to decrease the heart rate progressively, as required. Following this session, the patient was referred to the Emergency Room for a percutaneous transluminal coronary angioplasty plus stent.

Relying on objective data is important in such situations as self-reports might be biased or affected by *self-presentation*[4] [26], [27], [28] and, in turn, hide underlying conditions: here the patient reported a *very mild* Borg scale (7), which contradicts his high HR and what he told the medical staff at the intervention. Throughout this session, the number of posture corrections was also relatively high, which may also originate from the high exertion level and dizziness of the patient.

C. Long-term Perception of the Robot

Qualitative data was collected using the WAI questionnaire at the middle and end of the study, in order to analyse the long-term perception of the robot by the patient (Fig. 6). Results showed that the perception for *Goal*, *Task* and *Bond* was maintained highly positive throughout the CR programme, supporting our objectives with personalisation of the robot.

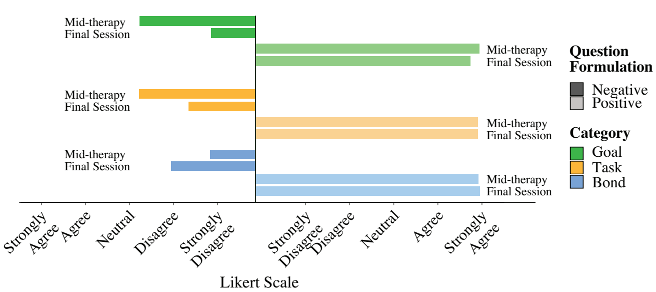

Fig. 6. Working Alliance Inventory (WAI) responses evaluated at the middle of the CR programme (18th session) and the final (35th) session.

In the case of negative formulation, the results decrease in *Task* and *Goal* category. These outcomes show that the negative perception of the robot decreases with time. The patient is less confused with the tasks (corrections) made by the robot during the rehabilitation, and the patient believes that the time spent with the robot is profitable more over the duration of the CR programme. Regarding the *Bond*, the negative perception worsen slightly. Detailed analysis of the open questions showed that the patient felt that the robot would no longer cooperate with him during the sessions if he did not make the corrections requested by the robot (e.g., cervical posture and the high HR confirmation).

The UTAUT questionnaire [13] results support that the patient perceived the robot and the CR programme as highly positive, strongly agreeing with 88.5% of the questions and agreeing with the social presence aspects and the robot's utility in therapy development, which is more positive than the perceptions of the non-personalised robot in [13]. Additionally, the personalisation aspects were all very positively perceived and enjoyed. The responses to the open questions further support the findings: *"I would recommend using the robot as it is a great help during the CR programme"*, *"The robot interacts in a positive way with me, it helps me along with the medical staff, and it is also a good tool for them"*.

D. Interactions with the Robot

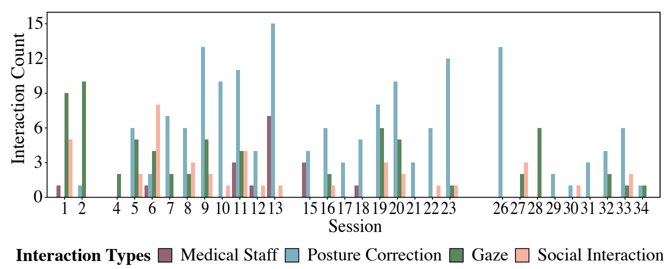

Fig. 7. Interaction results of the video analysis based on 30 sessions[2].

We analysed 30 recorded sessions[2] to observe the interactions with the robot throughout the CR programme (Fig. 7). Four types of interactions were analysed by an independent coder: (i) *Medical staff* interaction with the robot, which occurs when the medical staff interact with the robot either through responding to the robot's request for intervention during a critical high HR, or talks with the robot when checking the patient, (ii) *Posture correction* upon robot request, (iii) *Gaze* which indicates when the patient looks at the robot to pay attention and (iv) *Social interaction* that consists of the patient's verbal (e.g., thanking the robot after the personalised progress feedback given at the end of the session) and non-verbal (e.g., gesture to the robot after motivational feedback, or touch the head of the robot) communications with the robot.

The medical staff worked collaboratively with the robot to intervene in the sessions when necessary, such as for the 13th session which is discernible in Fig. 7, or to change the exercise intensity. The infrequent interactions indicate that the medical staff found the robot reliable and trusted it as a tool of monitoring the patient adequately and supporting the CR programme, which is in line with the perceptions of the clinicians from the focus group in [13].

[4]Conforming to normative behaviours to gain approval of another person.

[2]Results for sessions 3, 14, 24, 25 and 35 are missing due to technical problems with the recordings.

Regarding the number of warnings for cervical posture correction (in Fig. 4), the video analysis showed that the patient corrected his posture without fail upon a simple prompt by the robot.

While the *gaze* and *social interaction* were higher at the initial sessions due to possibly the novelty effect and the adjustment process to the technology, these interactions also occurred throughout the later sessions. Additionally, the video analysis showed that the patient is very focused on the exercise as expected, hence, the patient could mostly only look at the robot at the beginning of the treadmill exercise and at the end of the *cooldown* stage, which could have resulted in the low number of *gaze* and *social interactions* depending on the session intensity. Various types of *social interaction* were observed, such as talking to the robot (at session 33), mirroring the robot's gesture to the *Call medical staff* alert, reacting positively (e.g., smiling or thanking the robot) to the motivational feedback of the robot, touching (caressing) the robot (e.g., at the end of a session after the robot "sighed" going into sleep mode), talking to other patients about the robot's role and its benefits, and reacting negatively (e.g., frown) to the robot, in the case of misidentifications from user recognition, posture correction (once) and for the high number of alerts to the medical staff.

The user recognition performed poorly (14 out of 38 times[5]), due to the malfunctioning face recognition (13 times), including the first (enrolment) session of the patient. Since the user recognition uses online learning, this negatively affected the performance of the system. Nonetheless, the video analysis shows that out of 9 misidentifications, the patient reacted negatively only twice (i.e., the other times, he did not react). Moreover, the patient strongly agreed with *The robot recognises me correctly* in UTAUT.

Additionally, the video recordings showed that the patient responded to all the *Borg scale* and *High HR* warnings of the robot through the tablet due to the compulsory structure of the requests. Fig. 8 shows that initially, the patient had difficulty in interacting with the system, but he quickly adjusted to the system.

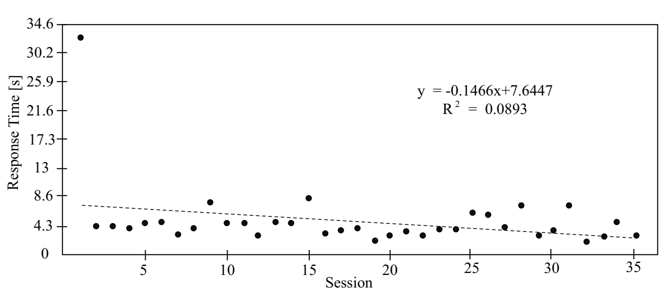

Fig. 8. Borg scale response time throughout the CR programme. Less is better.

Finally, the analysis of the patient's attendance shows that the patient attended the CR twice per week as required in 13 out of 18 weeks, missing more sessions in the beginning.

[5]Due to sensor connection problems, the system had to be restarted during the session in 3 occasions. Correspondingly, the robot recognised the patient again to start the session, thus, the total number of recognitions is 38.

V. DISCUSSION

The improved physiological progress of the patient (i.e., the increase in recovery HR and the intensity of the sessions) is the objective of the CR programme. Our results showed that the patient indeed improved and successfully completed the sessions, as established by the physiatrists.

While the CR programme could be successfully completed without the presence of a personalised social robot as shown in our previous work, the continuous monitoring and immediate feedback provided additional benefits to the patient and the medical staff, as highlighted by the alerts during the sessions, the corrections of the posture, the "critical" session and the long-term perception of the robot through *Task* and *Goal* components of WAI. The patient also acknowledged and remarked the usefulness of the robot over the conventional CR programme in UTAUT, open questions and while talking to other patients. In addition, our system relied on the collaboration of the medical staff with the robot, which, in turn, created a reliable system, trusted by the medical staff and used as a tool by them to support the CR programme and help detect critical conditions.

Through the personalisation of the robot, we aimed to increase the perceived sociability and social presence of the robot, and increase the patient's motivation, engagement and adherence. The video analysis shows that the gaze and social interaction with the robot were maintained throughout the CR programme, which is a valuable result showing that the patient did not lose interest in the robot throughout the long-term rehabilitation. Moreover, the patient (as well as the medical staff) acknowledged the robot as a social agent instead of just a tool, by verbally and non-verbally interacting with it. A detailed analysis of the perceived personalised aspects of the system showed that the patient positively reacted to the positive progress motivation given at the end of the session for having a lower number of problems in the session with *"Let's keep up the good work!"*. In fact, the patient verbally thanked the robot in three of these cases, which did not happen towards the other non-personalised behaviours. The patient negatively reacted to the misidentifications in user recognition, which may further support the social agent perspective, however, he very positively responded to the corresponding UTAUT question as well as to the other personalisation aspects, which suggests that personalisation mitigates the negative user experience [29].

While the positive formulation of the *Bond* category of WAI also shows that the sociability of the robot was perceived highly positive throughout the CR programme, the negative formulation shows an increase in the social presence of the robot, based on the detailed analysis that indicated the fear of losing cooperation, and hence increased pressure to comply with the robot. In addition, even though the patient was mostly focused throughout the *training* stage, thereby limiting the *gaze*, the numbers indicate that the patient paid attention to the robot, thereby recognising its presence.

Furthermore, the patient fully complied to the posture correction requests of the robot. Additionally, the increasing and frequent twice-weekly attendance of the patient suggest that the personalised attendance of the robot may have improved the adherence to the CR programme.

These findings suggest the importance of a personalised socially assistive robot in CR to help the patient and the medical staff for monitoring the rehabilitation progress within and throughout the sessions, maintaining the motivation and adherence in the long-term, and achieving compliance for the corrective measures.

VI. CONCLUSION

This detailed case study not only illustrates the potential of technology-supported cardio rehabilitation and the role a social robot can play in this, but demonstrates the potential of long-term personalised interaction. A major concern in rehabilitation is the drop out of patients, and this case study shows the potential of using social robots to mitigate this. The questionnaires and analysis of the video recordings of the sessions suggest that personalising the interaction is key to increasing the perceived sociability and social presence of the robot, and in turn, improving the patient's motivation, engagement and adherence.

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